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Art. VII. — *Researches concerning the Periodical Meteors of August and November.* By Sears C. Walker, A. P. S. Read January 15th, 1841 [before the American Philosophical Society, at Philadelphia, and published in their Transactions]. Philadelphia. 4to. pp. 53.

The falling star is so familiar to us that it rarely attracts more than a passing notice ; and the attempt to define, distinguish from one another, and classify, such fleeting phenomena has appeared a hopeless undertaking, and has only very recently been made with regular and systematic zeal. Crude hypotheses, atmospheric, volcanic, selenitic, and cosmical, had long been afloat in men's minds ; it had been conjectured that they might be gaseous explosions, electrical sparks, aerolites, or "world-chips." Light and flighty enough for entertaining academic discussion, they could not, however, command the careful research of earnest inquirers, until there was good reason to believe that they were not of the class of the inconstant *ignes fatui.* A multitude of speculations might be enumerated, but so weak and ill-supported that a single fact is enough to disperse them. At the very close of the last century, two college lads, Brandes and Benzenberg, students of Göttingen, instituted a series of exact observations, from which it appeared that these meteors move through the air with the average velocity of twenty miles in a second, as swiftly as the earth in its orbit. This astonishing velocity, which has been confirmed by Brandes's later observations in 1823, Quetelet's in 1824, Twining's in November of 1833, and Boguslawski's in 1836 and 1837, but which is only one tenth part of the speed according to Wartmann's determination in 1838, is altogether too great to have originated in any volcanic eruption, either lunar or terrestrial, or from any conceivable explosion, while it is much too small to be attributed to electricity. It seems, therefore, sufficient of itself to make a clear opening for the cosmical view, although it would be most presumptuous, upon this isolated fact, to build a complicated theory, and to fill space with myriads of little planets. It was also inferred from these different observations, that the velocity was not the same for all the meteors, but that it ranged from ten to two hundred and fifty miles per second, the least velocity being too great to belong to a satellite of the earth, and the greatest being tenfold more than that which would suffice to throw a body out of the region of the sun's influence. The height of the meteors, moreover, was found to vary from six to six hundred miles. No common character, in short, of any theoretical importance, was detected, and no principle established, which could serve as a means of classification. But, before some of these observations were made, a fortunate occurrence, skilfully improved, led to the discovery of such a principle, and, in 1833, a new view of the meteoric phenomena emanated from New Haven, which has since attracted the serious attention of the whole scientific world.

The great meteoric display of November, 1833, which was the occasion of these recent investigations, was one of the most sublime showers of fire of which we find any record in history. "Above, and all around the firmament," says an observer in Missouri, "thicker than the stars themselves, which were uncommonly bright, large, and beautiful, we beheld innumerable fire-balls, of a pallid color, rushing down, and, to appearance, across the sky, drawing after them long luminous traces, which clothed the whole heaven in majesty, and gave the air and earth a pale and death-like appearance." "It would be difficult," said Mr. Aikin, of Maryland, "for one who had not witnessed the grand exhibition, to conceive the effect of this uninterrupted succession of innumerable meteors, proceeding from a point so nearly vertical towards the whole circumference of the horizon, and this, too, during the stillness of night, and with an atmosphere perfectly transparent. It could only be compared to one grand and continued discharge of fireworks, occupying the whole visible heavens." An observer in Georgia, also, witnessed the phenomenon, and described it, but in such glowing language that we quote only two sentences, in which the most remarkable of the meteors is particularly described.

> "By far the most brilliant one which we saw, occurred at a few minutes past five in the morning, and seemed to announce, by its splendor, the *finale* of this grand exhibition of fireworks in the heavens. It seemed to pursue, as near as we could judge, a course from southeast to northwest, the ball being, apparently, five or six inches in diameter, with a train of from thirty to forty

feet in length ; the latter assuming, immediately on the passage of the meteor, a serpentine form, and diffusing a light upon the earth quite equal to that of the full moon, and remaining intense at least for forty or fifty seconds."

Mr. James Sperry, at Henrietta, New York, remarked upon this same meteor, that —

"it left a streak of light apparently as broad as the moon, and extending over at least thirty degrees of the arch of the heavens, which was visible three minutes, shining at first with such splendor that small objects on the earth could be as easily distinguished as at the full of the moon ; it was straight at first, but, after continuing about one minute, contracted and crooked in the middle, — the bend forming nearly a right angle with the other part, — and then gradually grew more dim until it disappeared."

It was also observed, by Professor Olmsted of New Haven, —

"to shoot off in the northwest direction, and explode a little northward of the star Capella, leaving, just behind the place of explosion, a phosphorescent train of peculiar beauty. This line was, at first, nearly straight, but it shortly began to contract in length, to dilate in breadth, and to assume the figure of a serpent drawing itself up, until it appeared like a small luminous cloud of vapor."

Mr. Palmer, of New Haven, —

"from seven o'clock in the evening had noticed a reddish vapor, which first appeared low in the south, but gradually rose up the southern sky to the zenith. It was very thin, but still obscured the smaller stars."

President Humphreys said, that —

"many persons became exceedingly alarmed ; the light was so intense that some were aroused from sleep by the brilliant illumination of their apartments, and were under the apprehension that their dwellings were in flames."

The meteors were visible throughout almost the whole of the United States, from Maine to Louisiana, and from Lake Huron to the Gulf of Mexico ; they were also seen in Mexico, in the islands of Cuba and Jamaica, off the Bermudas, and on board of the brig *Francia* in the Atlantic Ocean, at a distance of three hundred miles northeast of the Bermudas, and five hundred miles from the American coast. Accounts from all quarters were sent to Professor Olmsted, who took great pains to collect them, arranged them systematically, and published them in the twenty-fifth and twenty-sixth volumes of "Silliman's Journal," where the reader may find them, and, however far removed his tastes may be from dry philosophical inquiries, he will be fully rewarded by the entertainment which the perusal of them will afford. The only valuable observations, from a place without the apparent limits of the shower, were made in the Gulf of Mexico; and, since they have given rise to an important difference of opinion, which we shall not consider for the present, we venture to quote them at length.

"The ship *Junior*, Captain Gideon Parker, from Mobile for New York, was in the Gulf of Mexico, latitude 26° north, longitude 85⅓° west. Captain Parker, being on deck a little before three o'clock on the morning of November 13th, noticed several meteors, but not more than he had often seen before. Heavy dark clouds hung low in the northeast, from which the second mate (who held the watch before Captain Parker came on deck) said, that the first meteors he saw seemed to break like lightning. Above the clouds, which were from fifteen degrees to twenty-five degrees high, the sky was clear, and the stars bright as usual. About three o'clock, Captain Parker first noticed the unusual number of falling stars, and began to count their number, but was forced to desist by their rapid increase. For an hour and a half, Captain Parker observed them. During that time they were seen only in the northeast, above the cloud, and the eye at first would take in nearly the whole space of their action, which extended six or seven points along the horizon, and about forty-five degrees in altitude above it; but, towards the latter part of its obscuration, the space was more extended, say, twelve or fourteen points horizontally, and a few degrees higher in altitude. During its whole period of obscuration, *not one was seen in the west;* although Captain Parker looked particularly to this fact, and called the mate's attention to it at the time. Captain Parker distinctly remembers a radiant point in the northeast, from which all the courses were directed, some shooting horizontally, some vertically, and others at all inclinations between the two, but none upwards, — some shot towards the north, and some towards the east. This radiant, at first, held about forty-five degrees of altitude, but seemed to rise five degrees or ten degrees in the period of his observation; without, however, moving from the northeast at all. The meteors resembled common shooting stars, and were mostly as minute in magnitude as the stars themselves, — ten or twelve, however, would compare in size with the morning star. Some of the larger moved over a space of fifteen degrees to twenty, and some of them seemed to develope themselves not far from the point, and to go behind the cloud. All that descended low enough passed behind the cloud, — not one between the cloud and the observer. Near to the radiant the courses of some that were observed were very short, — not more than two or three degrees. All, both large and small, left a luminous trace, in which no prismatic colors were observed; and no one of the traces was observed to continue visible more than two seconds. The afternoon of the preceding day had been squally, and wind variable; but at the time of observation there was light wind from northeast.

"At nearly half past four, Captain Parker yielded the deck to his mate, who states, that, soon after he came on deck, the stars appeared passing over from the northeast into the west. In the west, their courses were very short, and they seemed 'just to let go their hold.' The ship was heading southeast. He continued on deck till eight o'clock in the forenoon. In the mean time, the meteors increased in number, and spread over the whole heavens, and were most brilliant about six o'clock. The sun rose at half past six." — *American Journal of Science*, Vol. xxv. pp. 399, 400.

The common point of radiation spoken of by Captain Parker, was also noticed by many other competent witnesses of the phenomena, and its existence has been unquestionably established by the collections and observations of Professors Olmsted and Twining. Mr. Olmsted said, that the meteors "commenced their progress at different distances from the radiating point, but their directions were uniformly such that the lines they described, if produced upwards, would all have met in the same part of the heavens. Around this point, or imaginary radiant, was a circular space of several degrees, within which no meteors were observed."

Mr. Twining, of West Point, said, that —

"there was a point a few degrees south and east of the zenith, which was evidently the *directrix* of all the apparent motions; and every luminous body, without exception, of those associated in the phenomenon, obeyed a regimen in relation to that point, which was such that every line and track of motion, if continued backward, would have passed, as nearly as the eye could discern, through that specific point. In the vicinity of that point a few star-like bodies were observed, possessing very little motion, and leaving very little length of trace; but, in their aspect, such as if a small nebula had softly swelled out from the heavens, gently elongated in its figure, and then as gently subsided. Farther off, the motions were more rapid and the traces longer; and the most rapid of all, and longest in their trace, were those which originated but a few degrees above the horizon and descended down to it. In these, the aspect might be compared to that of flaming sparks, driven swiftly athwart the sky by a strong wind."

President Humphreys remarked, that they "all appeared to move from a common centre, at or near the zenith." Professor Aikin said, that, "instead of the usual intermediate course of such meteors, these described paths in the direction of radii diverging from a central space. It was of no great extent, not longer, perhaps, than a circle ten degrees in diameter, without accurately defined outlines, but perfectly clear. From this centre, as a radiating point, proceeded the meteors, in numbers exceeding the visible stars, and in intensity of light often rivalling the rays of the full moon." The testimony of other observers, of Mr. Barber, of Frederick, Maryland, J. L. R., of Worthington, Ohio, Mr. Palmer, of New Haven, and of many persons in Georgia, New York, Pennsylvania, and Ohio, was equally strong and decisive. This characteristic feature, forming a nucleus about which observations and hypotheses may cluster and crystallize into theory, has given an unexpected impulse to science in this direction. Observers in Europe and America have watched the motions of the shooting stars with renewed zeal; Quetelet abroad, and Herrick at home, have diligently digested the observations; and the result has already been a close approach to demonstrating the proposition, that, *whenever there is an unusual abundance of igneous meteors, the greater proportion of them radiate from a fixed space in the heavens.*

In their meteoric investigations, Biot, Chasles, Herrick, and Quetelet have searched voyages and travels, old records and chronicles, and Quetelet's last catalogue, published in 1841, contains 115 probable instances of great showers of stars before the year 1833. The subject is far from being exhausted even now, for a writer in the *Deutsches Viertel-jahrs Schrift* has, from an imperfect examination of Vögel's Leipzig Chronicles, added several to the list. In most of these cases, nothing was recorded but the bare fact of the great numbers of falling stars; and no notice was taken of their character and direction. Frequently, however, it is stated, that they fell on all sides, which is, at least, an approximation to a common direction, and, in fifteen cases, this common direction is expressly mentioned. Thus, in February, 836, they "fell from east to west"; on the 13th of November, 899, "the stars falling, in Egypt, from northeast to southwest, were extraordinarily agitated, so that no one could fix his eyes upon the heavens." "On the 30th of October, 901, King Ibrahim Ben Ahmet died, and, on the same night, many stars fell, as if they had been thrown into the air, to the right and left, from a culminating point, like rain. Hence this year has been called the 'year of stars.'" On the 15th of October, 1743, in England, "A clear night, great shooting of stars between 9 and 10 o'clock; all shot from S. W. to N. E. One like a comet, in the meridian, very large, and like fire, with a long, broad train after it, which lasted several minutes; after that, was a train like a row of thick small stars for twenty minutes together, which dipt N." "During the great heat which the pestilential malady of the summer of 1798 developed, the shooting stars were incredibly numerous for many nights, near the 9th of August. Almost all proceeded from N. E. to S. W., and succeeded one another so rapidly that the eye of the observer was kept constantly in motion." On the 11th of November, 1799, a most remarkable shower, to which we shall repeatedly refer, was seen by Humboldt and Bonpland in Cumaná, to rise in the northeast and ascend towards the zenith. Upon the nights of the 9th of August, 1799 and 1813, of the 25th of November, 1822, the 11th to the 13th of November, 1832, and the 12th of December, 1830, many meteors fell, most of them passing from the northeast to the southwest. Similar observations were made and recorded on the nights of the 12th of August, 1824, the 3d, the 14th, and 15th of August, 1826, many meteors falling, and, in most cases, passing towards the southwest.

It will be observed, that the meteors which move in a common direction are classed as radiating, on account of the well known principle of perspective, that parallel straight lines will always appear to diverge from a point, which is called their *vanishing point*. Thus, the pole-star is the vanishing point of lines parallel to the earth's axis; and a shower of stars, which shot from north to south, in the direction of these lines, would appear to radiate from the pole-star. Since the year 1833, observations have been made with more care; it has been determined, that the average number of meteors which may be seen in an hour, on common nights, by a single observer, is about eight; and that, upon the nights of the 12th to the 14th of November, from 1834 to 1838 inclusive, upon those of the 9th to the 11th of August, 1837 to 1842 inclusive, upon those of the 6th of December, 1838, and of the 19th of April, 1839, there were unusual "meteoric abundances," and there seemed to be a common space of radiation. The place at which the meteor began, and that at which it ended its course, have been noted, in many cases, with extreme precision. Nearly 600 of these observations, which have been published, have been patiently and rigidly scrutinized, and we are convinced of the reality of the radiation, although, as will be seen in the sequel, it is of a somewhat different nature from that which is assumed by the partisans of the cosmical theory. From observations made at Königsberg and Berlin, on the nights of the 10th and 11th of August, 1837 and 1839, by Dr. Busch, Professor Erman, and others, it appears that, out of 398 meteors observed and registered, 288, or nearly three fourths of the whole number, radiated from a space in the heavens of about 20 degrees in radius. Such coincidences cannot be accidental, unless all regularity is accident. This uniformity of direction is not apparent upon ordinary nights, when the number of meteors is not unusually great.*

It may be thought, that the observations are still too few to establish so fundamental a proposition as the one proposed, that all meteoric showers radiate; and that it can only be inferred from them, that there are often radiating showers; or, at most, that, upon those nights in which many meteors are seen to radiate, the whole number of meteors is unusually great, so as to leave the unconformable meteors about as many as they are on ordinary occasions. This would of itself be a most valuable result; but, while we admit, that there are reasonable grounds for hesitating to advance farther with the present *data*, we must urge, as a weighty argument for the higher conclusion, that a large proportion of the many showers which have been observed since 1833 are of the radiating class, while not one has been shown to be of a different character. Farther investigations may modify this result, and prove that the proposition is not universal; but we are strongly inclined to believe, that its claims will be generally admitted, and that it will remain the first great law in this branch of meteorology.

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* Thus, of 34 meteors, observed in 6 hours on the 13th of November, 1839, at the Königsberg observatory, only 11, or about one third, radiated from a space of 20 degrees in radius; and in 4½ hours on the 14th of November, 1826, of 34 meteors registered at Berlin, only 9 partook of such a radiation; only two out of 17 meteors observed in showers on the 12th of November, 1839, at Cölen; and only 15 meteors out of 54 observed in 8 hours on the 12th of November, 1838, by Mr. Birt, at Whitechapel, London.

The radiating, or, as more usually styled, the convergent meteors stand, then, as a distinct class, separate from those which are unconformable or *sporadic*. The feature by which they are characterized is to be carefully distinguished from another phenomenon, which, however intimately connected with it in theory, is radically different as a matter of simple observation. It seems to be the opinion of Messrs. Fitch and Herrick, that the average direction of the meteors, on all nights, is from the point towards which the earth is moving; not that many of them proceed from this point, or from the surrounding space, but about as many pass from one side of this point as from the opposite. Such a construction only of the views of these observers could be reconciled with the results of the astronomer Littrow's observations, which were continued nightly for about a year, from 1837 to 1838, without the detection of any convergent point, except upon the nights near the 10th of August, and the 12th of November.

The frequent mention of the two periods of the year just named, in connexion with the showers referred to in this article, may have been noticed by the reader, and he may desire to learn, whether these nights are unusually favored by the shooting stars, or by the star-gazers. Probably by both, at least within the last few years; but this brings us to the most interesting phenomenon connected with the convergent meteors, that of their *annual periodicity*, or regular recurrence at the same seasons of the year. A different kind of periodicity was suggested by Ritter in "Gilbert's Annalen," who attributed all the igneous meteors to atmospheric processes, which come to their highest state of activity in periods of nine or ten years, and then abate during the interval; and he brings forward the years 1788, 1798, and 1807, as instances of this unusual activity. Humboldt thus alludes to this hypothesis; "The periodicity of the phenomenon adds to the interest which it inspires. During some months, in our temperate zone, Brandes has counted from 60 to 80 shooting stars in a night; while, in other months, they have exceeded 2000. If one is so brilliant as to have the apparent magnitude of Sirius or Jupiter, it is sure to be succeeded by others. When shooting stars are unusually frequent during one night, this abundance generally lasts for several weeks. It might be said that, in the upper regions of the atmosphere, near the extreme limit where the centrifugal force is balanced by gravity, there is, periodically, a peculiar disposition for the production of fire-balls, shooting stars, and the *aurora borealis.* Does the periodicity of this great phenomenon depend on the state of the atmosphere, or on some foreign substance, which the atmosphere receives as the earth advances in the ecliptic? Of all this we are as ignorant now as at the time of Anaxagoras." Ritter's periodical years, not being sustained by observation, are of little value, and were soon forgotten. Quite different is it with the annual periods, the idea of which was first fully and distinctly conceived and announced by Professor Olmsted. But, as usual in the case of important discoveries, some credit is here due to others. It seems, indeed, when the world is ripe for a new truth, as if nature sowed it broadcast, and its germs are found in various minds, although in one only it may have sprung up and borne fruit. The first thought of periodicity, it seems, occurred in an obscure way to Mr. Palmer, of New Haven, so that he even predicted the splendid display, after which the conception became fully matured. "Being abroad in the earlier parts of the night, and having observed an unusual number of falling stars, he was induced to read over an account of the meteors described by Andrew Ellicott, which occurred November 12th, 1799. This being the same time of year, his curiosity was excited, and he mentioned to members of his family his expectation of a similar phenomenon." The coincidence with the same shower of 1799, as it was observed and described by Humboldt and Bonpland, was also noticed, independently of each other, by Professor Olmsted, by a writer in the Boston Centinel, and by Mr. Hildreth, of Marietta, Ohio. The development of the idea, however, and its defence, were reserved for Professor Olmsted, and he was ably seconded by Professor Twining and Mr. Herrick. For five years after 1833, meteoric showers were seen, as it was supposed, at New Haven and other places, about the 12th of November. During these five years, also, they were carefully looked for at Philadelphia without success ; at the request of Professor Bache, circulars were sent to the different military posts, inquiring if any unusual meteoric display had been witnessed at the anniversary of 1834, to which the replies were, with a single exception, decidedly unfavorable. The November period could not have been sustained against this severe, but thorough and impartial, investigation, particularly as its most zealous partisans admit, that the shower of this period has ceased since 1838, if the way had not been cleared for it by the establishment of the August period. Much of the controversy was undoubtedly verbal, and turned upon the question, How many meteors make a shower ? To evade the answer, meteorologists have sacrificed grammatical scruples to necessity, and find less difficulty in maintaining that there were " meteoric abundances " in these five years. These " abundances," altogether inferior to that of 1833, had the distinctive character of convergency, the importance of which did not, from the outset, escape the discernment of Professor Olmsted. The history of the November period before 1833 will probably be received with more favor after the perusal of the stronger evidence for that of August.

The first sure record of the August period is in 1451 ; after which there is one in 1723, one in 1724, and no other until 1779 ; but, during the sixty-four succeeding years, down to the present time, a shower of meteors at this season is recorded in thirty-three different years, or more than half of the whole number. Among these are included the six years since the periodicity was first detected, the omission of which would leave fifty-eight previous years, with twenty-seven recorded anniversaries. When it is added, that, during this time, only fifty-two nights were noted in which showers were observed, the proof of this period not only seems complete, but much more than any one could have anticipated, who reflected upon the facility with which these phenomena escape notice. It is also remarkable, that many of the early August showers were observed by men whose distinguished reputation elevates their testimony above all dispute ; such as Sir William Hamilton, Spallanzani, Brandes, Priestley, Forster, Howard, Professor Stevelly, and Chladni. This period is called "Quetelet's" by Walker, who attributes to this philosopher its first announcement in 1836 ; but we perceive that, in a letter to Mr. Paine, it is claimed by Littrow ; and it is worthy of notice, that Mr. Locke, of Cincinnati, in 1834, two years before the discovery of the periodicity, determined the position of the point of radiation.

Returning, now, to the history of the November shower, we find the first distinct record of it in 899, after which it was not noticed till 1602, nor again till the great shower of 1799. The latter was more remarkable for the brilliancy of its meteors, and the extent of country which it visited, than that of 1833 ; it was seen in Cumaná, on the borders of Brazil, in French Guiana, in the Bahama Channel, on the continent of North America, in Labrador, in Greenland, and many shooting stars were noticed on the same day in some places in Germany. During the forty years from 1799 to 1838 inclusive, the shower of this period was observed fourteen times, or nine times during the thirty-five years from 1799 to 1833, in which time only seventeen showers are recorded exclusively of those occurring in August. In the number of its showers, then, Olmsted's period is decidedly inferior to Quetelet's ; and in the character of them, also, excepting the two great exhibitions of 1799 and 1833 ; but, with some hesitation, the scientific world seems so far inclined to its reception that the burden of proof is already thrown upon the negative ; and, for ourselves, we are not disposed to take up the gauntlet in opposition.

Besides these two periods, others have been proposed, with much less evidence to recommend them ; as the 10th of April, at which season a shower was recorded five times within the half century preceding the year 1123, but has since been wholly lost, unless we listen to the unsatisfactory suggestion, that it has been reproduced in modern times at the later period of the 20th of April, of which there are two instances in the present century. There have, also, been five showers, upon dates near the 6th of December, since the year 1740, and four upon the 2d of January in the years 1835, 1838, 1839, 1840, which, from their proximity to each other, are more interesting, and less likely to be deceptive.

The accurate observations of the August and November periods have elicited another important fact, which is, that the radiating space is the same throughout the night, at different places, and in different years. In November, its centre is in the neck of the constellation Leo, and in August, it is in the right shoulder of Perseus.

The four phenomena of radiation, periodicity, fixedness of the space of radiation, and the great velocity of the meteors, compose the foundation upon which the cosmical theory has been erected, and no attempt has been made to account for them upon any other hypothesis. This theory, which was first proposed in an organized form by Chladni, met with no favor, was abandoned by its author before his death, and afterwards was quite neglected, till it was revived by Olmsted and Twining, in 1833. In the list of its supporters are now enrolled the names of many of the most distinguished astronomers of Europe, as Arago, Biot, Bessel, Olbers, Boguslawski, Littrow, Quetelet, and Erman. It is developed by Mr. Walker of Philadelphia, in the article before us, with sound learning, unbiased, discriminating judgment, and ingenious and original research. This memoir is one of many rich donations which the venerable Philosophical Society of Philadelphia has lately made to the treasury of American science, and is in all respects deserving of the epithet "remarkable," which has been applied to it by the distinguished secretary of the Royal Academy of Brussels.

The rings of Saturn are thought by some of the most judicious astronomers not to be continuous in their structure, but to consist of the union of millions of small bodies. Each of these bodies would be invisible from the earth, if it were separated from the rest, as the whole ring is, when it is presented to us edgewise. Of the whole mass united at Saturn, then, nearly one *per cent.* is in small detached portions revolving about the primary, and the inquiry naturally arises, Is this phenomenon unique, or are there corresponding phenomena in other parts of the solar system? The satellites are common to Jupiter, Herschel, and the

Earth ; but the smaller fragments are nowhere else found in that conglomerate state requisite for their detection. And yet, upon a belief that the Deity has adopted a uniform organic system in the production of the planets, such as is pointed out by the beautiful nebular hypothesis of Herschel and Laplace, we are unwilling to admit that similar small bodies are wholly wanting in other parts of the solar system, and seize with avidity upon the indications of them in our own vicinity, afforded by the aerolites. But the founders of the cosmical theory have gone much farther ; finding in the four telescopic planets, of which the largest has a diameter of only eighty miles, in the comets with their ever separating tails, in the zodiacal light, and in the distant nebulæ, proofs that the celestial spaces are filled with bodies of all varieties of magnitude and density, they venture to include in the same class the fire-balls and falling stars. Having different orbits, they are seen, when they are near the earth, shooting in all directions ; rarely, however, do they tend towards the zenith, because they cannot pass through the solid earth, so that those which are seen to rise, are only the few, which, coming from the other side, approach so near to our planet as not to be beyond the reach of our vision. In the earlier part of the night, too, when the point of the heavens from which the earth is moving, is high above the horizon, the greater portion of those which are seen must have overtaken the earth in its orbit, and, consequently, if they belong to the solar system, their velocities in the direction of the earth must be more than sixteen and a half geographical miles in a second, and less than twenty-three and a half miles. But, in the morning, when the point towards which the earth is moving is elevated, the visible meteors may have any direct motion less than sixteen and a half miles in a second, and any retrograde one more than twenty-three and a half miles.. The number of meteors on ordinary nights should, then, increase as the night advances, which is amply confirmed by observation. Their average direction should also agree with our interpretation of Mr. Fitch's views, and be from the point towards which the earth is moving ; or rather, it should, in high northern latitudes, be to the north of this point, and the reverse in southern latitudes. Mr. Walker thinks, that the observed law of distribution of the known comets, by which "four fifths have their perihelia beneath that of the earth, and three fifths beneath that of Venus," leads, by analogy, to the inference, "that the perihelia of the meteors are gradually aggregated together as the distance from the sun diminishes; that by far the greater part of these bodies never reach the earth's mean distance." He also infers, "that a great portion of those seen on ordinary nights, having their perihelia inferior to Mercury, must, at the time of visibility, be generally near their aphelia, and have a small velocity; and, moving in all directions, the mean relative direction must be nearly opposite the observer's true direction, and the actual velocity of any single meteor, resolved in the plane normal to the observer's direction, must be small, and must exhibit itself as a small discrepancy from the mean convergent point of the evening." This ingenious speculation is supported by the fact, that the comets are resisted while they are within a distance less than that of Venus from the sun; for Mr. Walker's suggestion is most plausible, that the "aggregation of these small asteroids within the mean distance of Mercury may produce a sensible effect in resisting the progress of a body so light as Encke's comet, which the younger Herschel supposes to be incomparably more rare than the thinnest clouds which float in the upper regions of the atmosphere." It seems superfluous, however, to adopt this view into the cosmical theory, in order to account for the average direction and velocity of the meteors. It would, indeed, lead to a more definite phenomenon, — to an imperfect radiation on all nights, which seems to be contradicted by Littrow's observations, but may be hereafter established by a longer series, which has just been commenced, with this object especially in view.

The independent meteors present, however, but one phase of the cosmical theory, and would furnish too small a base for so vast a fabric. The complete development is contained in the following propositions from Mr. Walker's memoir;

> "That, while the general law of meteoric distribution prevails in the planetary space, portions of this space have, besides the average number conformable to this law, special clusters, groups, or flocks of great extent, possibly composing entire rings, or lenses, embracing the sun."
>
> "That the individuals composing these clusters have similar elements of elliptic motion, and continue to move round the sun

in a plane, which, for a considerable period, undergoes but little change in space.

"That in such a plane there may be an indefinite number of these irregular groups at various mean distances from the sun; or there may be a tendency to the formation of a continuous, or imperfect and interrupted ring, the ring itself being a conic section, probably an ellipse. The ring of Saturn furnishes such an analogy in a secondary system, and, according to Cassini and Laplace, most probably the zodiacal light in the solar system."

From this simple and comprehensive theory, the phenomena of convergence, periodicity, and fixedness of the radiating space, are direct and obvious corollaries. The shooting stars are raised by it from the class of *ignes fatui* to the dignity of astronomical bodies, whose orbits are to be determined and calculated upon the principles which are applied to planets and comets; they become the subjects of Kepler's laws, and their philosophy is that of the Principia. Most of the planets are visible throughout their orbits, so that the slightest inequality of their motions can be ascertained with numerical precision, and their computation is facilitated by the near approach of their paths to exact circles. The comets are seen for a few weeks or months at a time, are identified in case of their return, and are observed to move in exceedingly elliptical orbits, so that the parabola performs the office of the circle in simplifying the calculations. But the meteors are seen only for a few seconds, are often lost by impinging against the earth, or, if they pass by, leave no trace by which they can be recognised, should they ever chance to reappear. The determination of their orbits would, therefore, at first sight, appear to be a hopeless undertaking. It is not so; their proximity to the earth, which enables us to see them, gives immediately their distance from the sun, which must, at the time of observation, be the same as that of the observer; and thus we obtain, without any labored calculation, one of the most important elements, and usually the most difficult one to be ascertained. The centre of the radiating space shows, moreover, the common direction of the convergent showers, and the only *datum* which remains, in order completely to fix the position of the orbit, is the velocity of the meteors. When the same shooting star has been observed at different places, and the positions of the points of its appearance and disappearance carefully noted, the actual length of its path can often be computed with accuracy, and the duration of its passage gives the desired velocity. Unfortunately, the longest time, during which a meteor is visible, is only about four seconds, and the error of half a second in its observation is, consequently, a very serious one ; so that the computed velocity may be incorrect to an eighth, or even a fourth part of its whole amount. Such was the case with the serpentine meteor of 1833, the observations upon which were collated by Mr. Twining, and he has proved that the length of its visible path differed very little from fifty-five miles, while the estimated duration of its visibility varied from about two and a half to more than three seconds. By adopting three seconds as the most probable estimate, he obtained eighteen and one third miles per second for the meteor's relative velocity. Combining this *datum* with the other observed elements, Mr. Walker has carefully computed the orbit of the November shower, and it follows from his results, that its perihelion distance is only one hundred and ninety thousand miles. But the sun's radius is four hundred and forty-six thousand miles, so that the shower would be obliged to pass directly through the sun. As this cannot be, we are forced to modify Mr. Twining's estimate, and the change of a single mile is enough to escape this difficulty. The time of revolution is also found to be about one hundred and thirty days, which is more than one third of a year. A shorter period than this would be altogether impossible ; we cannot, therefore, meet the same cluster of meteors every November, unless their period is annual, or semi-annual. With the period of a year, Mr. Walker shows that the observed velocity of the meteors should be thirty-three miles per second, and, with that of half a year, twenty-seven miles ; either of which is inconsistent with Mr. Twining's computation, and, therefore, inadmissible. By the cosmical theory, we are thus driven to the hypothesis of a ring of meteors surrounding the sun, as the only possible method of accounting for the recurrence of the November showers.

On the 10th of August, 1837, four meteors were simultaneously observed at Berlin and Breslau, of which the direction was from the radiating space corresponding to that period ; the average length of their paths was forty-six and a half miles, but the duration of their visibility is not known.

To ascertain this point, we resort to the questionable evidence derived from the observations of another, at a different time and place ; "Mr. Custodes found, from ninety-eight shooting stars, seen on the 9th of August, 1837, at Dusseldorf, that the mean duration of visibility was one and a fifth seconds ; that of twenty-eight of the largest size, one and three quarters seconds ; and none over three seconds." Two of the meteors above given were of the first magnitude, one was small, and the fourth was of the average size. Supposing, then, three of them to be of the mean, and one of the longer duration, we obtain one and a third seconds for the average duration, and thirty-five miles per second for the relative velocity. The proper allowance for the earth's velocity leaves for the actual velocity of the meteors twenty-four and a half miles per second, which is sufficient to carry them off to an infinite distance from the sun in a hyperbolic orbit. The relative velocity must, indeed, be less than thirty-three and one third miles per second, which corresponds to a parabolic orbit. The duration of one and three quarters seconds gives a relative velocity of twenty-six and a half miles, an actual velocity of seventeen miles, and a period of revolution which is a little more than a year. The annual period is shown by Mr. Walker to correspond to a relative velocity of twenty-five and one fifth miles, which would give for the average passage of our four meteors about two and six sevenths seconds. This period would then be quite admissible, if it could be reconciled with the observations in the opposite portion of the earth's orbit ; that is, with those made about the 7th of February, at which time not a single shower occurs in Quetelet's catalogue, until they were particularly looked for, and, after this time, only in the year 1840. We do not, therefore, hesitate to reject this period of the year, and also that of the half year, for which Mr. Walker gives the relative velocity of twelve and three quarters miles per second, which would require a duration of nearly four seconds for the four meteors. For the August, as well as the November shower, therefore, the meteoric ring seems the necessary resort for the advocates of the cosmical theory.

Mr. Erman and others contend, that these results are confirmed by some accidental observations of striking obscurations of the sun and shooting stars, seen in the day time, about the end of February, and the middle of May, at which times we are on the opposite side of the rings, but we regard them as too vague to be valuable as evidence. Mr. Erman has also undertaken to prove, that there is an important diminution of temperature about the 7th of February and the 12th of May, as if a body were at that time interposed between the earth and the sun ; this ingenious attempt has not been sufficiently successful to gain any proselytes to the doctrine, and it is not confirmed by the probable velocity of the August meteors, which indicates that they are superior, and not inferior, to the earth's orbit.

Not without reluctance do we now approach the most ungracious part of our task, that of opposing the cosmical theory, without proposing a substitute. To make a negative argument is proverbially easy, but to persuade men of its truth is difficult ; a state of disbelief and unsettled opinion is so unpleasant and so galling to human pride, that the world is ever ready to fly from it into the arms of any plausible and seductive error. If the wildest hypotheses find advocates who even boast of their spiritual and mystical faith, and who can believe without comprehending, it cannot be surprising that due weight may not have been given to all the objections which might be urged against a theory so ably sustained by facts and philosophy. We begin our attack with disclaiming almost every argument which Mr. Galloway has advanced against the cosmical theory, as trivial and unimportant. First, the fact that, on the periodic nights, meteors are seen to shoot in every direction, is not a substantial objection, for there is just as good reason for the visits of the unconformable meteors on these nights as on any others ; nor, secondly, should we rely upon the probability that they are self-luminous ; for the principal proof of this, the very great height of some of them above the atmosphere, evinces only that they are not of terrestrial origin ; and, thirdly, with regard to the immense velocity, which Wartmann has observed in some instances, while it is too great for a body of the solar system, it is also too great for one derived from the earth, and it shows, perhaps, that, while there are meteors revolving about the planets, and others about the sun, there is still a third class, which move through space, from star to star. Wartmann, it is true, inferred from their rapid progress that they were of electrical origin, which is equivalent to confessing his total ignorance of their nature. Galloway's fourth objection, that they are not oftener attracted to the earth, is unintelligible, but appears to depend upon a false impression, that the shooting stars are supposed to be solid masses, so that they could be discovered if they were to fall to the ground. But his fifth and final objection is of radical importance, that they have been observed by Brandes and Wartmann to move directly from the earth in a path which, being produced backward, would pass directly through it. We do not, however, feel justified in pressing it, since Bessel has "shown, that every instance, in which Brandes's computations gave an upward motion of a meteor, may be made to indicate the reverse, by applying a correction of the observed points of beginning and end of the apparent path of a meteor, not much exceeding the probable error of such observations"; and it is not impossible, that Wartmann's cases will yield to the same method of examination.

The first difficulty which meets us, as a serious obstacle to a belief in the cosmical theory, is the obvious one of the great thickness required for the rings. The November shower occurred in 1813, as early as the 8th of the month, and in 1826, upon the 6th; in 1836, 1837, and 1842, it occurred on the 15th. The August shower, similarly, was seen on the 6th, in the years 1784 and 1819; on the 7th, in 1451 and 1784; on the 8th, in 1781, 1784, 1801, 1835, and 1836, and lasted till the 15th in 1823, 1826, 1827, and 1834. The earth must, then, be nine days in passing through each of these rings, and they must, consequently, be about fifteen million miles thick, or twelve million miles, after allowing for our oblique passage through them. This is an eighth part of the sun's distance, and more than thirteen times the sun's diameter, whereas the thickness of Saturn's rings is only one seven hundredth part of the diameter of the planet. Such immense rings are not impossible, but they are singularly disproportioned to the transient phenomena by which they are indicated.

Our second objection arises from the magnitude of the space from which the meteors appear to radiate. After making every allowance for inaccuracy of observation, we have not been able to reduce this space into dimensions below a circle of forty degrees in diameter; nor has an honest regard to the facts, uninfluenced by any peculiar faith or skepticism, permitted us to draw a smaller circle, and exclude all those meteors from participation in the phenomena of radiation, whose paths would not, when produced, pass through that circle. Any attempt to do this is sure to leave the number of unconformable meteors unusually great, at the expense of the shower, and the too hastily rejected meteors have a convergent character as earnestly demanding explanation as the primary phenomenon. Of the two hundred and eighty-eight convergent meteors, observed at the August periods in 1837 and 1839, at Königsberg and Berlin, one hundred and four radiated from a space of five degrees in radius ; sixty-four more were added by increasing the radius of the space to ten degrees ; sixty-three more by increasing it to fifteen degrees ; and the remaining fifty-seven, by extending it to twenty degrees. Instead of being precisely parallel, therefore, the relative paths of some of the meteors must make an angle with the mean direction of at least twenty degrees. The meteors are so light, that their mutual influence upon each other's motions must be too small to be appreciable, and the only important difference of their actual directions must, therefore, arise from the essential diversity of their orbits. But no orbit can differ from the mean orbit more than enough to enable the meteor to pass from one side of the ring to the other in the interval of half its period of revolution. Here is a source from which a deviation of four degrees may be derived in the case of the great ring twelve million miles thick. This velocity might be greatly magnified, if the relative velocity of the meteors were small ; but, great as it is, there cannot be an augmentation of more than twenty-five *per cent.*, or one degree. An authority to which we would willingly yield has privately suggested, that the remainder of the deflection may arise from the impinging of the meteors against the surface of the atmosphere. To this we reply, that such an effect should be nearly the same upon all the meteors which strike the atmosphere at the same time, and, consequently, at the same angle, and should vary with the hour of night, so as to give a sensible motion to the point of radiation ; and that the meteor would not be so much affected at the instant of entering the atmosphere, without being afterwards perceptibly retarded and curved in its course. The only way, which we perceive, of accounting for this perplexing phenomenon, is boldly to quadruple the already enormous thickness of the rings, and, as the deviation of the meteors is equally great in every direction, and upon each night of the observation, the dimensions must likewise be extended in the direction of the sun. What have we now ? A cylindrical ring, of which the section is forty-eight million miles in diameter !

Thirdly, we are not satisfied of the fixedness of the radiating space ; that it is fixed during the night is a fact that seems, indeed, to be tolerably well established, although Mr. Twining's comparison of the observations of 1833 suggests a reasonable doubt even upon this point ; but the radiant does not appear to occupy the same part of the heavens at different places. The demonstration of this has been ably and, as it seems to us, justly exhibited with regard to the shower of November, 1833, by Professor Twining. He has drawn up a table of the declinations of the radiant, given by various observers, or computed independently one of another from their accounts, without any effort at reconciliation. We copy it with the addition of a single column. In the first column is the observer's name, in the second, his latitude, in the third, the declination of his radiant, and in the fourth, a declination which is calculated upon the assumptions, that the New Haven observation is correct, and that the declination increases with the decrease of the latitude of the observer, at the rate of nineteen degrees of declination to ten degrees of latitude.

Observer.	Observer's North Latitude.	N. Declination of Radiant.	Calculated Dec. of Rad.
Mr. D. A. Strong	42° 52′	17°	17°
Mr. F. Merrick	41 33	19¼	19½
Prof. Olmsted	41 18	20	20
Mr. J. L. Riddel	40 4	21⅝	22¼
Prof. Aiken	39 40	23¾	23
Prof. Thomson	34 30	33	33
Capt. Parker	26 0	49	49

The close coincidence of the two last columns of this table is strong evidence of the correctness of the assumed change of declination in the position of the radiant. The accuracy of the observations upon which the table is constructed is shown by Professor Twining to be complete, except in the case of the two last observations, of Professor Thomson and Captain Parker. Professor Thomson's observation is changed by Mr. Walker from thirty-three to twenty-three degrees, without any reason being assigned, and that of Captain Parker is wholly set aside by him, as uncertain. But Professor Twining's estimate from Professor Thomson's *data* is only three degrees more than Mr. Dunster's observed declination in 1836 ; and it is singular, that, if it is substituted for Mr. Walker's, it gives, with the omission of Captain Parker's, a mean of twenty-two degrees for November, 1833, which is the same with that obtained by Mr. Walker for the other years. Professor Thomson's statement is, that "the meteors fell towards the earth at an angle of about 75° with the horizon, moving from the east towards the west ;" and he afterwards adds, that "the position of the apparent radiating point may readily be found on a celestial globe by noting the latitude of the place, 34° 30′ north, and the time, namely, five o'clock, A. M., together with the angle of fall above mentioned." Upon which Professor Twining justly observes, that, "from the nature of the *data*, namely, the general course of the meteors and the angle of their descent, it is uncertain whether Professor Thomson intended to be understood as speaking with precision ; yet so much as this is certain, that, if the declination had not varied northward considerably, when compared with the same at New Haven, the course of the meteors at five o'clock would have lain far north of west, and the radiant would have wheeled round rapidly towards the south, as morning approached." The number given in the table for Professor Thomson's declination precisely coincides, it is proper to remark, with his own account. Even without Captain Parker's observation, the other *data* are sufficient for our purpose, but his statement, already given, appears to us so precise, so perfectly consistent with itself and the other observations, and so decidedly at variance with the New Haven position of the radiant, that we are fully persuaded of its correctness, and strenuously oppose its rejection. The New Haven radiant was nearly to the east of Captain Parker, and rose fifteen degrees in the course of an hour ; whereas the declination of the table corresponds most minutely with Captain Parker's account of a point in the northeast, which rose about ten degrees in an hour.

Our position is, therefore, fully sustained by the shower best fitted to test it, from the comparative facility of observation. In confirmation of this local variation of the radiant, we do not dare to rely upon the constantly observed excess of five degrees in the declination of the New Haven radiant at the November period, over those of New York, West Point, and other places, because we doubt the accuracy of almost all the observations which have been made in this country upon the smaller showers, and of all, indeed, which have been made in any place whatever, without being accurately registered. In all these cases, we are persuaded, that the mind of the observer is influenced by his prejudices, and, however honest and sincere he may be, he is sure to see the meteors radiating from the point which he has previously determined. For the same reason, we do not dwell upon the observations at the Vienna observatory, on November 13th, 1838, when one hundred and sixty-seven meteors were seen in an hour, of which Mr. Littrow "ascribes the convergent point to the earth's motion in space." But Humboldt and Bonpland's description of the great shower of November, 1799, plainly indicates a radiating point far to the north of Captain Parker's, and having a northern declination of at least sixty degrees; for it was below the horizon at a time when the neck of Leo was at an elevation of from ten to forty degrees. "The direction of the meteors," says Humboldt, "was regularly from north to south; they filled a celestial space extending from the northeast thirty degrees to the north and south. Through an amplitude of sixty degrees, they were seen to rise above the horizon at E. N. E. to E., traverse arcs larger or smaller, and fall to the south, after having followed the direction of the meridian. Some attained forty degrees in altitude, all surpassed twenty-five or thirty degrees." The accurate observations of the August period exhibit the same difference in the position of the radiant. Thus, in 1837, it was six degrees farther north at Berlin than at Breslau, and, in 1839 and 1840, four degrees farther north at Königsberg and Philadelphia than at Berlin; this is the comparison of nicely computed results, in most of which, the probable error is supposed by the astronomers to be about two degrees, and in no instance to exceed three degrees.

In August, 1838, Herschel's radiant, at Collingwood in England, was γ Persei, and in 1839 it was β *Camelopardi*; while, in 1840, Schaeffer's radiant at Jamaica was one third of the way from ε to ι *Cassiopeæ*. Such local differences in the position of the radiant are utterly inexplicable upon the cosmical theory.

Our examination of the phenomena has thus led us to the conclusion, that, while no other than the cosmical theory can explain a precise and limited convergence, periodicity, and fixedness of the radiating point, of the shooting stars, each of these three phenomena, as observed, is of so decidedly indefinite a character as to be irreconcilable with this theory, and shows it to be, at the utmost, merely an uncertain approximation to the truth. We have waived some arguments, which might fairly be adduced, from the great velocity with which the meteors have recently been observed to radiate in November; from the striking coincidence, that there is the same point of radiation in the August and December showers, and in that of November, 1841, observed by Quetelet; and from the local character of the meteoric phenomena referred to by Humboldt. He observes that they are more frequent over land than sea, and this seems to be confirmed by many of the facts connected with the showers of 1799 and 1833, the latter of which was magnificent at New York two hours before it was noticed at New Haven, and was witnessed in all its splendor at the Bermudas, Cuba, and in Florida, while it was comparatively small to Captain Parker, in the Gulf of Mexico, and to the captain of a brig in the Atlantic. We have also passed by the objections which occurred to us, when we found that the showers were sometimes seen while the radiant was depressed far below the horizon. Thus, the shower of 1833 commenced at Charleston, South Carolina, and near Augusta, in Georgia, at nine o'clock in the evening, while the radiant was twenty degrees below the horizon. Nor have we alluded to the startling fact, that many shooting stars have been observed, at the November period, to proceed directly towards the radiating space. This was first noticed by Professor Lovering, in 1838; and was exhibited by ten of the thirty-four meteors observed at Königsberg in 1839, by ten of the thirty-four observed at Berlin in 1836, and by eleven of the fifty-four observed at London in 1838. Galloway thought, that the great accumulation of periods, which now occur almost once a month, discredited the whole of them. The objection is, however, more plausible than sound, for, if they are all true periods, they cannot disprove one another; still less can the falsely assumed periods be used as a weapon against the true ones. In order, now, not to be misunderstood, we unequivocally state our firm belief in the periods, and in the fundamental phenomena upon which the cosmical theory is founded ; but we are not convinced of the truth of the theory itself, or of its sufficiency to explain the phenomena.

Another subject of discussion regarding the meteors is the source of their light. It has been generally supposed to be derived from their passage through the air, which is condensed before them, and raised to a high temperature. But the very great difference of the heights at which they are first seen, varying from eight to five hundred miles, is a serious objection to this view, and quite conclusive, if we admit the accuracy of the upper limit, which is given by Wartmann, and which must be far above the surface of the atmosphere. Wartmann and his son have also observed a few meteors, which disappeared in their course, and then reappeared ; one, seen by himself, having remained invisible for three fourths of a second. Such a phenomenon seems hardly to be accounted for by the atmospheric hypothesis. As the meteors, when seen, are generally in the earth's shadow, they cannot derive their light from the sun, and it has, therefore, been supposed that they are self-luminous. The luminous train, which is so often left behind, is thought to be in the atmosphere, because it appears to be carried along by the wind. The color of the meteors is very variable, being, in different cases, red, white, blue, and green ; and, in some fire-balls, various hues have been observed at the same time. Sound has sometimes been thought to proceed from them, but this fact is very doubtful. Professor Olmsted inclines to the belief, that, in the shower of 1833, "hissing noises, like the rushing of a skyrocket, were heard, or slight explosions, like the bursting of the same bodies. These comparisons occur too uniformly, and in too many instances, to permit us to suppose that they were either imaginary or derived from extraneous sources." These sounds were not, however, heard by Professor Olmsted himself, Dr. Smith, Professor Aiken, and many other observers ; and President Humphreys said, that it was "a perfectly silent dance of the stars."

The convergent shooting stars must be carefully distinguished from other meteoric phenomena ; not that they may not be theoretically connected with them, but their characteristic phenomena are essentially different. They are not to be confounded with the aerolites, for these, as far as their motions have been calculated, have been found to have a relative velocity too small to carry them beyond the earth's sphere of attraction, so that they may either be terrestrial satellites, or the products of a lunar volcano. They must also be distinguished from the *aurora borealis* ; which affects the magnetic needle, has the magnetic pole for its radiant, is seen as often at one season as at another, and has a different character of periodicity ; for Mairan has shown, that, after being frequently seen for several successive years, it disappears for a long period. Quetelet and others have, however, thought that these phenomena are connected together, and with storms, earthquakes, &c. But the links or laws of connexion have in no case been discovered, and Quetelet is undoubtedly pursuing the only path which can ever lead to their discovery, that of careful inductive observation. Much time has been wasted in useless speculation, and in vain attempts at solving the obscure problems here involved, by some less wearisome process than that of laborious research. But the Gordian knot can only be cut by the sword of an Alexander ; and the rewards of genius are inexorably denied to the impatient and superficial guesser.

ART. VIII. — 1. *Final Report on the Geology of Massachusetts.* By EDWARD HITCHCOCK, LL. D., Professor of Chemistry and Natural History in Amherst College, Geologist to the State of Massachusetts, etc. Amherst : J. S. & C. Adams. Two Volumes. 4to. pp. 831. Plates 55.

2. *Elementary Geology.* By EDWARD HITCHCOCK, LL. D. Third Edition, revised and improved. With an Introductory Notice, by JOHN PYE SMITH, D. D. New York. 8vo. pp. 348.

THE honor of the first movement in the great work of Geological Surveys in the United States belongs to North Carolina. In 1823, at the suggestion of Professor Olmsted, the legislature of that State commissioned him to execute a